15: Astrobiology and the Search for Extraterrestrial Intelligence

Learning Objectives

- Explore the various hypotheses about abiogenesis.
- Describe the field of astrobiology.
- Explore various examples of extremophiles and how they can be used in the search for extraterrestrial life.
- Describe the conditions that a habitable world is expected to have and where in the galaxy they may be found.
- Discuss the search for extraterrestrial intelligence, the probability of another intelligent civilization existing in the galaxy, and ask why we haven't seen any signs of one.

Where did life come from?

Is there life on other worlds?

Could there be intelligent aliens with which we may be able to communicate?

There are probably no questions more profound about our own existence that these. To understand if life exist on other worlds, we need a greater understanding of life and how it many have begun here on Earth.

But what is life?

This is one of those questions that seems easy at first, but it is more difficult that initially thought. Are bacteria alive? What about viruses? If we found life on another world, would be able to even identify it? There are some agreed upon characteristics that something must have to be considered alive:

Order: organisms have some form of organism. This may consist of multiple, specialized cells working together. But even single-cell organisms have complex internal structures which can carry out complex chemical reactions in a controlled environment.

Response to the environment: Organism respond and grow together stimuli. Mobile animals travel toward resources and away from danger. Planets grow in response to sunlight, water, and available nutrients. Even bacteria can move toward certain chemicals or light.

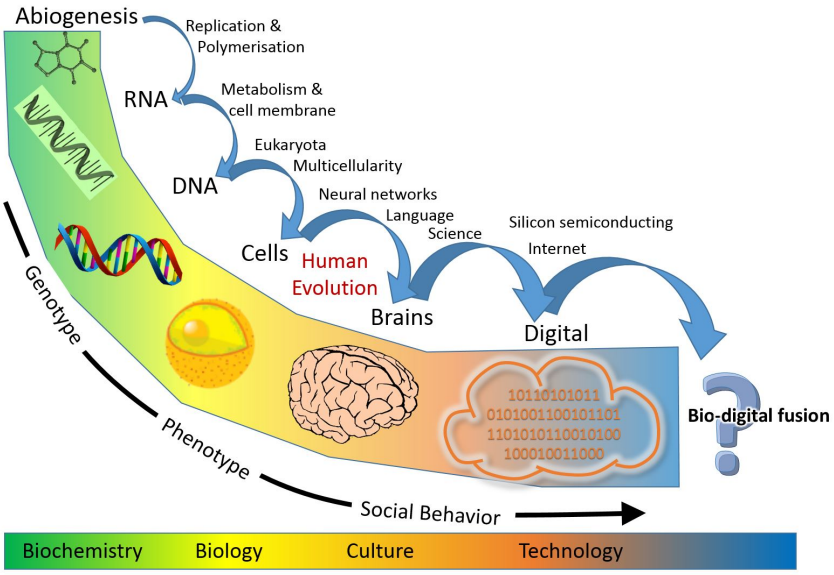
Reproduction: Cells divide and reproduce. Multicellular organisms reproduce either sexually or asexually. All life as we know it uses the self-replicating molecules of DNA to produce offspring that have similar traits as the parent.

Growth: All organisms grow occurring to predictable patterns governed by their inherited DNA.

Homeostasis: Organisms absorb nutrients and expel wastes. This helps them maintain homeostasis, or stable internal conditions, which is necessary to carry out the chemical reactions and molecular machinery to keep the organism functioning.

Energy processing: Organisms make use of sources of energy to power their metabolism and maintain homeostasis. This energy may come from sources like the sun for photosynthesis or by taking in energy by consuming other organisms.

Evolution: Populations of organisms can respond to changes in the environment by adapting. Traits that enhance survival and reproduction are more likely to be passed onto future generations. They will therefore become more prevalent in the population over succeeding generations. As a result, the average characteristics of members of the population will change over time.



based on: Gillings, M. R., Hilbert, M., & Kemp, D. J. (2016). Information in the Biosphere: Biological and Digital Worlds. *Trends in Ecology & Evolution*, 31(3), 180–189. http://escholarship.org/uc/item/38f4b791

Evolution of life.

https:/commons.wikimedia.org/wiki/File:Major_Evolutionary_Transitions_digital.jpg;

Lots of things may meet some of these criteria. Fire, for example, takes in energy and can grow and reproduce, but it is not organized and does not evolve. A car is organized and processes energy to power its energy, but it cannot reproduce or evolve. Crystals are organized and can growth, but they cannot evolve or process energy. Organisms, from the single-celled bacterium to human beings meet all the above characteristics. On the other hand, viruses meet most of these criteria, but cannot reproduce on their own. They require a host cell whose machinery they can hijack to make new viruses. For that reason, many biologists do not consider viruses to be living organisms.

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